Discharge of the Congo River Estimated from Satellite Measurements

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1. ABSTRACT

Although Central Africa's Congo River is the world's second largest river based on drainage area and discharge; little in-situ hydrologic data has been collected from this area. This lack of data limits our understanding of the water cycle throughout the region. The region receives significant rainfall on both sides of the equator at different times of the year, due to the annual south-north migration of the Intertropical Convergence Zone (ITCZ, a low-pressure zone around the equator which leads to heavy precipitation). Many satellite missions have been launched that image the earth using visible band frequencies or radar technologies (e.g., LandSat and various SAR missions, respectively), but none are specifically designed to measure surface water variables such as river discharge and changes in lake storage. Our objective is to determine the discharge of the Congo River and several of its largest tributaries (Sangha, Ubangi, Aruwimi, Tshuapa, Kasai), using only remotely sensed data. We use remote sensing data from these various satellite missions for measurements of channel width, length and water surface elevation. Data sets showing open water in channels (the JERS-1 SAR data from the Global Rain Forest Mapping project, or GRFM) are combined with data sets showing water surface elevation (Shuttle Radar Topography Mission, or SRTM) to determine the slope of the water surface. By using measurements of width, estimates of depth can be approximated by noting that discharge in short reaches should remain constant and thus width variations can indicate depth variations. Manning's n is estimated within reasonable bounds for rivers having cohesive sediments along their banks. These variables are combined utilizing Manning's Equation to estimate the discharge of the river. We calculate slope for 100's of kilometer long reaches by fitting polynomials to SRTM derived water surface heights and their respective flow distances. Our results show discharge variations of various tributaries and the Congo main stem for February 2000, the time of the SRTM overpasses.

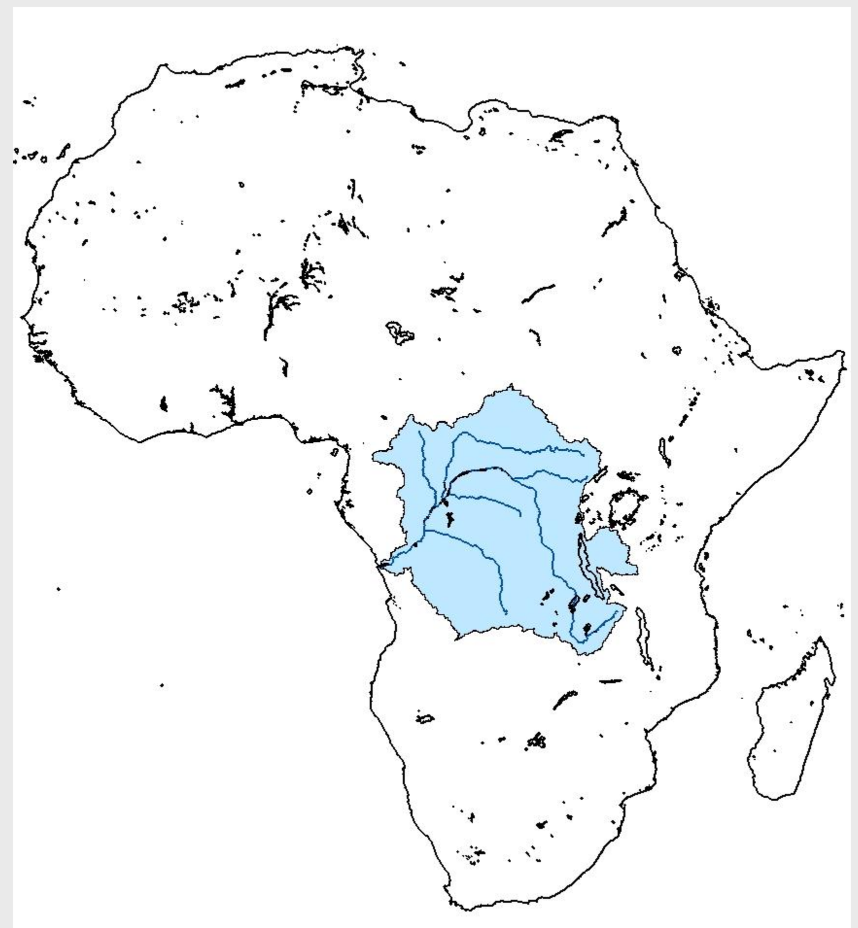


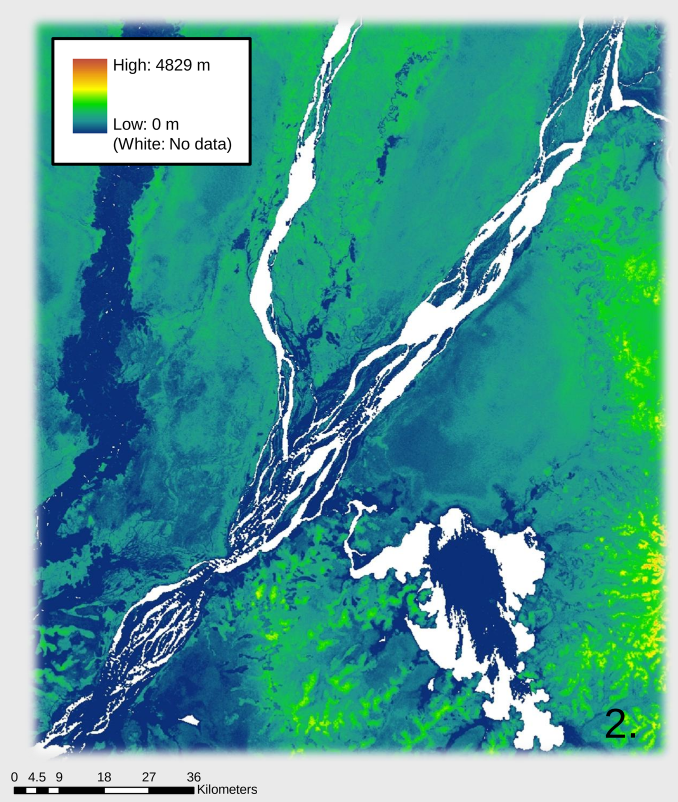
Figure 1. Region of focus: Congo River Basin in Central Africa

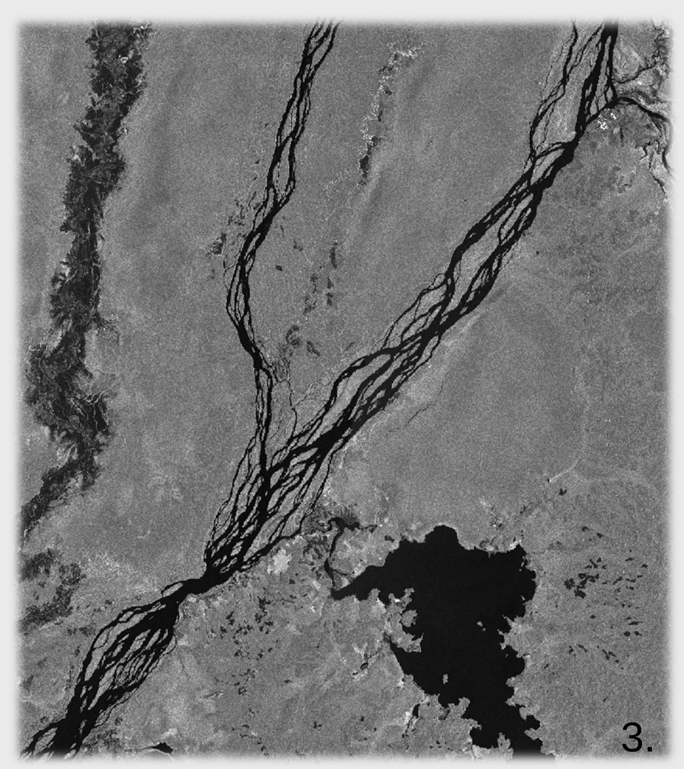
2. METHODS

Manning's Equation

n is Manning's channel roughness coefficient,
z is the hydraulic radius (depth),
s is the slope and
w is the river's width.

$$Q = \frac{1}{n} w z^{\frac{5}{3}} S^{\frac{1}{2}}$$





Images created using Shuttle Radar Topography Mission (SRTM) and Global Rainforest Mapping project (GRFM) data, Rosenqvist et al. (2000). Image 2 shows the SRTM Digital Elevation Model (DEM) data for a small area in the northeast Congo River basin. Figure 3 shows the same area with GRFM brightness which assigns a value to each type of land, dark areas represent water. 4 is a derivation of image 3, showing a binary classification. This was instrumental in calculating heights along the channel.

3. DATA COLLECTION

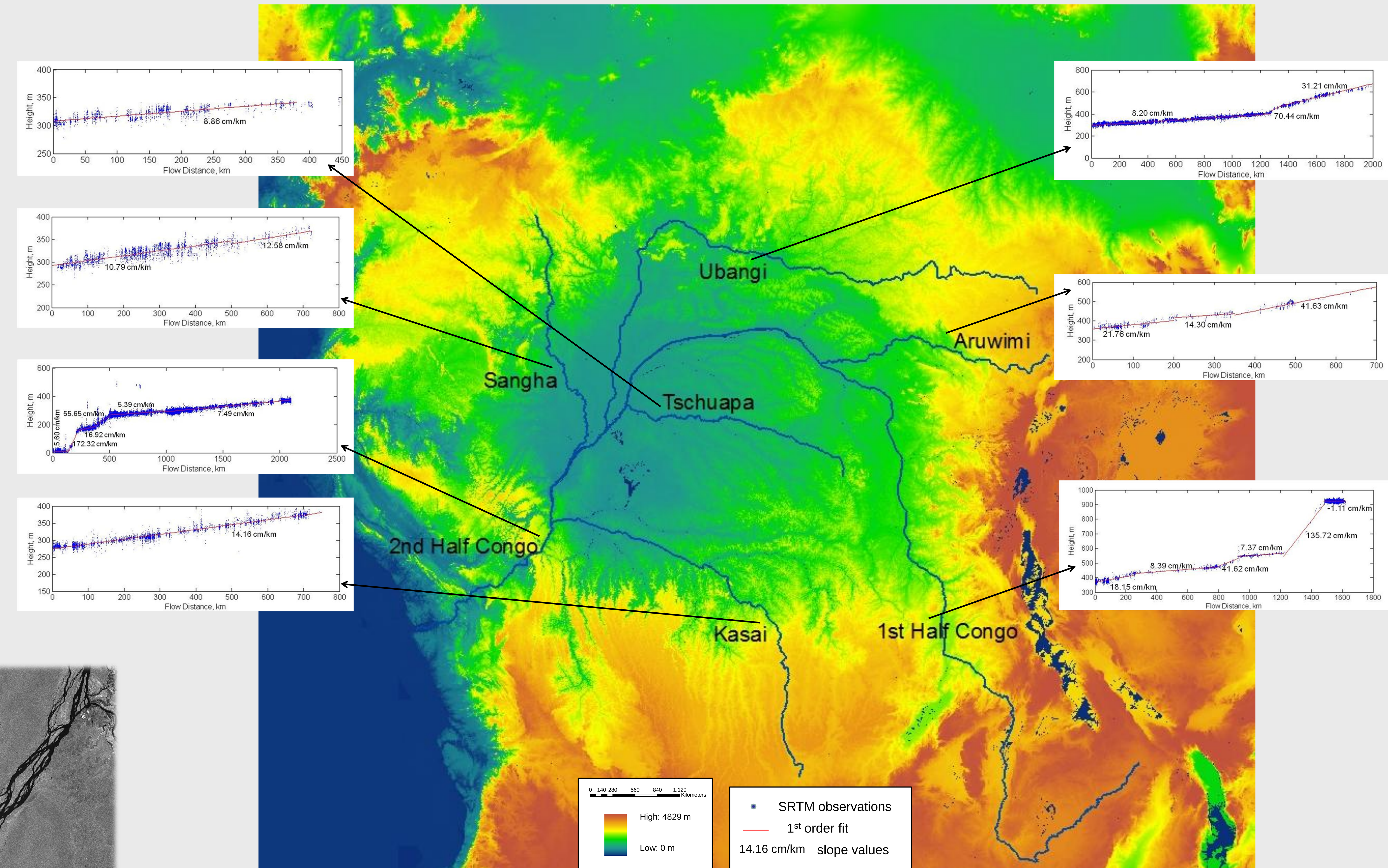


Figure 5. Shuttle Radar Topography Mission (SRTM) elevation data for the entire Congo River basin. Inset plots show height and flow distance data with slope calculations for tributaries and the Congo main stem.

4. RESULTS

The results gained from this research help to provide discharge estimates for a data poor region. Moreover, they demonstrate the estimation of discharge from purely remotely sensed data. The study's results are unique because we will not get single points of data along the river, but a continuous stretch of data. We can also check that our data sets are self-consistent: we will be able to take discharge data from two tributaries and compare the values to where the two converge. The data should reflect a sum of the discharges.

5. FUTURE WORK

These preliminary results give us a clear picture of the slopes found in the Congo Basin. We expect to find channel widths, changes in water storage between high and low water and the total discharge in the upcoming months. The RivWidth algorithm (Pavelsky 2008) will measure river width, despite the braided nature of the river channel. Depth values will be estimated based on width measurements and open channel hydraulics.

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